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XV. *On the motions of the Eye, in illustration of the uses of the muscles and nerves of the orbit.* By CHARLES BELL, Esq.
Communicated by Sir HUMPHRY DAVY, Bart. P. R. S.

Read March 20, 1823.

THE object of this paper is to explain the reason of there being six nerves distributed to the eye, and consequently crowded into the narrow space of the orbit.

But before it is possible to assign the uses of these nerves, we must examine the motions of the eye more minutely than has hitherto been done, and try to comprehend the offices to be performed. Much as the eye has been studied, the frame-work which suspends it, and by which it is moved and protected, has not received the attention it deserves. Yet this frame-work, or apparatus, is not less calculated to renew our wonder, than the properties of the organ itself.

It is therefore necessary to divide the paper into two parts. *First*, to show the uses of the apparatus which is exterior to the eye-ball; and then, in the *second place*, to consider how the nerves minister to these offices.

PART I.

Of the muscles and frame-work which are around the eye-ball.

Even grave and learned men have eulogized this organ as the most necessary to intellectual enjoyment, and which ranges from the observation of the fixed stars, to that of the expres-

sion in the human face. But this admiration is in part misplaced, if given to the optic nerve and ball of the eye exclusively ; since these high endowments belong to the exercise of the whole eye, its exterior apparatus as much as to that nerve which is sensible to the impressions of light. It is to the muscular apparatus, and to the conclusions we are enabled to draw from the consciousness of muscular effort, that we owe that geometrical sense, by which we become acquainted with the form, and magnitude, and distance of objects. We might as well expect to understand the uses of a theodolite, or any complicated instrument for observations, by estimating the optical powers of the glasses, without considering the quadrant, level, or plumb-line, as expect to learn the whole powers of the eye by confining our study to the naked ball. I propose to show, that we must distinguish the motions of the eye, according to their objects or uses, whether for the direct purpose of vision, or for the preservation of the organ: that the eye undergoes a revolving motion not hitherto noticed ; that it is subject to a state of rest and activity, and that the different conditions of the retina are accompanied by appropriate conditions of the surrounding muscles ; that these muscles are to be distinguished into two natural classes ; and that in sleep, faintness, and insensibility, the eye-ball is given up to the one, and in watchfulness, and the full exercise of the organ, it is given up to the influence of the other class of muscles: and finally, that the consideration of these natural conditions of the eye explains its changes as symptomatic of disease, or as expressive of passion.

Motions of the eye-ball and eye-lids.

Two objects are attained through the motion of the eye-ball. First, the controul and direction of the eye to objects; secondly, the preservation of the organ itself, either by withdrawing the surface from injury, or by the removal of what is offensive to it. Without keeping this distinction before us, we shall not easily discover the uses of the parts.

There is a motion of the eye-ball, which, from its rapidity, has escaped observation. At the instant in which the eye-lids are closed, the eye-ball makes a movement which raises the cornea under the upper eye-lid.

If we fix one eye upon an object, and close the other eye with the finger in such a manner as to feel the convexity of the cornea through the eye-lid, when we shut the eye that is open, we shall feel that the cornea of the other eye is instantly elevated; and that it thus rises and falls in sympathy with the eye that is closed and opened. This change of the position of the eye-ball takes place during the most rapid winking motions of the eye-lids. When a dog was deprived of the power of closing the eye-lids of one eye by the division of the nerve of the eye-lids, the eye did not cease to turn up when he was threatened, and when he winked with the eye-lids of the other side.

Nearly the same thing I observed in a girl whose eye-lids were attached to the surrounding skin, owing to a burn; for the fore part of the eye-ball being completely uncovered, when she would have winked, instead of the eyelids descending, the eye-balls were turned up, and the cornea was moistened by coming into contact with the mouths of the lacrymal ducts.

The purpose of this rapid insensible motion of the eye-ball will be understood on observing the form of the eye-lids and the place of the lacrymal gland. The margins of the eye-lids are flat, and when they meet, they touch only at their outer edges, so that when closed there is a gutter left between them and the cornea. If the eye-ball were to remain without motion, the margins of the eye-lids would meet in such a manner on the surface of the cornea, that a certain portion would be left untouched, and the eye would have no power of clearing off what obscured the vision, at that principal part of the lucid cornea which is in the very axis of the eye ; and if the tears flowed they would be left accumulated on the centre of the cornea, and winking, instead of clearing the eye, would suffuse it. To avoid these effects, and to sweep and clear the surface of the cornea, at the same time that the eye-lids are closed, the eye-ball revolves, and the cornea is rapidly elevated under the eye-lid.

Another effect of this motion of the eye-ball is to procure the discharge from the lacrymal ducts ; for by the simultaneous ascent of the cornea, and the descent of the upper eye-lid, the membrane on which the ducts open is stretched, and the effect is like the elongation of the nipple, facilitating the discharge of tears.

By the double motion, the descent of the eye-lid and the ascent of the cornea at the same time, the rapidity with which the eye escapes from injury is encreased. Even creatures which have imperfect eye-lids, as fishes, by possessing this rapid revolving motion of the eye, avoid injury and clear off impurities.

I may observe in passing, that there is a provision for the

preservation of the eye, in the manner in which the eye-lids close, which has not been noticed ; while the upper eye-lid falls, the lower eye-lid is moved towards the nose. This is a part of that curious provision for collecting offensive particles towards the inner corner of the eye. If the edges of the eye-lids be marked with black spots, it will be seen that when the eye-lids are opened and closed, the spot on the upper eye-lid will descend and rise perpendicularly, while the spot on the lower eye-lid will play horizontally like a shuttle.

To comprehend certain actions of the muscles of the eye, we must remember that the caruncle and membrane called *semilunaris*, seated in the inner corner of the eye, are for ridding the eye of extraneous matter, and are in fact, for the same purpose with that apparatus which is more perfect and appropriate in beasts and birds.

The course of our enquiry makes some observation of these parts necessary.

In quadrupeds there is a gland for secreting a glutinous and adhesive fluid, which is seated on that side of the orbit next the nose ; it is quite distinct from the lacrymal gland ; it is squeezed by an apparatus of muscles, and the fluid exudes upon the surface of the third eye-lid. This third eye-lid is a very peculiar part of the apparatus of preservation. It is a thin cartilage, the posterior part of which is attached to an elastic body. This body is lodged in a division or depression of the orbit on the side towards the nose. When the eye is excited, the eye-ball is made to press on the elastic body and force it out of its recess or socket ; the consequence of which is the protrusion of the cartilaginous

third eye-lid, or *haw*, as it is termed in the horse. By this mechanism the third eye-lid is made to sweep rapidly over the surface of the cornea, and by means of the glutinous fluid with which its surface is bedewed, it attaches and clears away offensive particles.

In birds, the eye is an exquisitely fine organ, and still more curiously, and as we might be tempted to say, artificially protected. The third eye-lid is more perfect; it is membranous and broad, and is drawn over the surface of the eye by means of two muscles which are attached to the back part of the eye-ball, and by a long round tendon, that makes a course of nearly three parts of the circumference of the ball. The lacrymal gland is small, and seated low, but the mucous gland is of great size, and seated in a cavity deep and large, and on the inside of the orbit. As the third eye-lid is moved by an apparatus which cannot squeeze the mucous gland at the same time that the eye-lid is moved, as in quadrupeds, the oblique muscles are particularly provided to draw the eye-ball against the gland, and to force out the mucus on the surface of the third eye-lid. It flows very copiously; and this is probably the reason of the smallness of the proper lacrymal gland which lies on the opposite side of the orbit.

We already see two objects attained through the motion of these parts: the moistening the eye with the clear fluid of the lacrymal gland, and the extraction or protrusion of offensive particles.

There is another division of this subject no less curious; the different conditions of the eye during the waking and sleeping state, remain to be considered. If we approach a person in disturbed sleep when the eye-lids are a little apart,

we shall not see the pupil nor the dark part of the eye, as we should were he awake, for the cornea is turned upwards under the upper eye-lid. If a person be fainting, as insensibility comes over him the eyes cease to have speculation; that is they want direction, and are vacant, and presently the white part of the eye is disclosed by the revolving of the eye-ball upwards. So it is on the approach of death; for, although the eye-lids be open, the pupils are in part hid, being turned up with a seeming agony, which however is the mark of encreasing insensibility.

It will now be admitted that the variety of motions to which the eye is subjected, require the complication of muscles which we find in the orbit, and it must be obvious to the most casual observer, that unless these various offices and different conditions of the eye be considered, it will be in vain to attempt an accurate classification of the muscles of the orbit.

Of the actions of the muscles of the eye, and their natural classification.

The muscles attached to the eye-ball are in two classes, the recti and obliqui. The recti muscles are four in number, and come from the bottom of the orbit, and run a straight course forwards and outwards; they embrace the eye-ball, and are inserted at four cardinal points into it. The obliqui are two muscles having a direction backwards and outwards;*

* We may say so, for although the superior oblique muscle comes from the back of the orbit, yet, by passing through the trochlea, it has a course backwards and outwards to its insertion.

they embrace the eye-ball, one passing over it obliquely, the other under it obliquely.

That the recti muscles perform the office of directing the axis of the eye, turning it round to every point in the sphere of vision, there are many proofs. In the first place, their origin, course, and insertion, accurately fit them for this office ; and they are obviously equal to it, unassisted by other muscles. In the next place, from man down to the cuttle-fish, the voluntary motions of the eyes are the same, and the origin, course, and insertion of these muscles are similar, while the other muscles vary with the change of apparatus which is around the eye.

The oblique muscles of the eye stand contrasted with the recti in every respect, in number, size, and direction. Yet it is a received opinion, that they antagonize the recti, and keep the eye suspended. To this opinion there are many objections. 1. In creatures where the eye is socketed on a cup of cartilage and cannot retract, the oblique muscles are nevertheless present. 2. Where a powerful retractor muscle is bestowed in addition to the recti muscles, the oblique muscles have no additional magnitude given to them. 3. In matter of fact, the human eye cannot be retracted by the united action of the recti as we see quadrupeds draw in their eyes, which is an argument against these muscles being retractors, and therefore against the obliqui being their opponents, to draw it forward.

To these, other objections, no less strong, may be added. We have just found that certain very rapid motions are to be performed by the eyeball ; now it can be demonstrated, that a body will be moved in less time by a muscle which is

oblique to the line of motion, than if it lay in the line on which the body moves. If the oblique muscles were either opponents or coadjutors of the recti, there appears no reason why they should be oblique, but the contrary ; for as the points of their insertion must move more rapidly than those of the recti, they are unsuitable. On the other hand, that there may be no difference in the time of the action and relaxation of the several classes, we see a reason why one rectus should be opposed by another, and why there being occasion for one oblique, its antagonist should also be oblique.

In proportion as a muscle gains velocity by its obliquity, it loses power ; from the obliquity, therefore, of these muscles believed to be opposed to the recti, and from their being two of them to four of the latter, they are disproportioned in strength, and the disproportion proves that the two classes of muscles are not antagonists.

By dissection and experiment it can be proved, that the oblique muscles are antagonists to each other, and that they roll the eye in opposite directions, the superior oblique directing the pupil downwards and outwards, and the inferior oblique directing it upwards and inwards. But it is proved that any two of the recti muscles are equal to the direction of the pupil in the diagonal between them, and there is no reason why an additional muscle should be given, to direct the pupil upwards and inwards more than upwards and outwards, or downwards and inwards. It is evident then, that the oblique muscles are not for assisting the recti in directing the eye to objects, but that they must have some other appropriate office. If we proceed farther, it must be by experiment.

Experimental enquiry into the action of these muscles.

I. I divided the *superior rectus* or *attollens* in a rabbit, and felt something like disappointment on observing the eye remain stationary. Shortly afterwards, on looking to the animal while it was feeding, I saw the pupil depressed, and that the animal had no power of raising it.

The explanation I conceive to be this: during the experiment the eye was spasmodically fixed by the general action of the muscles, and particularly by the powerful retractor, a muscle peculiar to quadrupeds. But on the spasm relaxing, and when the eye was restored to the influence of the voluntary muscles, the recti, the voluntary power of raising the eye being lost by the division of the superior muscle, the eye was permanently depressed.

II. Wishing to ascertain if the oblique muscles contract to force the eye-ball laterally towards the nose, I put a fine thread round the tendon of the superior oblique muscle of a rabbit, and appended a glass bead to it of a weight to draw out the tendon a little. On touching the eye with a feather, I had the pleasure of seeing the bead drawn up. And on repeating the experiment, the thread was forcibly drawn through my fingers.

By experiments made carefully in the dead body, (having distended the eye-ball by dropping mercury into it to give it its full globular figure) I had found that the action of the superior oblique muscle is to turn the pupil downwards and outwards, and that the inferior oblique just reverses this motion of the eye. In the above experiment there is abundance of proof that the superior oblique muscle acted, and yet the

pupil was not turned downwards and outwards, therefore both oblique muscles must have been in action. Their combined action draws the eye-ball towards the nose.

In the violent spasmodic affection of the eye, when it is painfully irritated, I believe that all the muscles, both of the eye-ball and eye-lids, are excited. In quadrupeds, I have ascertained that the oblique muscles act when the haw is protruded, but I have also found that the retractor oculi alone, is capable of forcing forwards the haw.

But quadrupeds having an additional apparatus of muscles to those of the human eye, are not suited for experiments intended to illustrate the motions of our eyes. The monkey has the same muscles of the eye with man.

III. I cut across the tendon of the superior oblique muscle of the right eye of a monkey. He was very little disturbed by this experiment, and turned round his eyes with his characteristic enquiring looks, as if nothing had happened to affect the eye.

IV. I divided the lower oblique muscle of the eye of a monkey. The eye was not, in any sensible manner, affected; the voluntary motions were perfect after the operation.

V. On holding open the eyes of the monkey, which had the superior oblique muscle of the right eye divided, and waving the hand before him, the right eye turned upwards and inwards, while the other eye had a scarcely perceptible motion in the same direction. When the right eye was thus turned up, he seemed to have a difficulty in bringing it down again.

From these experiments it is proved, that the division of the oblique muscles does not in any degree affect the voluntary motions by which the eye is directed to objects.

This cannot however be said of the involuntary winking motions of the eyes. We have seen that in winking to avoid injury, the oblique muscles were in operation ; and that the inferior oblique muscle gained in the power of elevating the eye-ball by the division of the superior oblique, its opponent.*

On the two conditions of the eye, its state of rest, and of activity.

The eye is subject to two conditions : a state of rest with entire oblivion of sensation, and a state of watchfulness, during which both the optic nerve and the nerve of voluntary motion are in activity. When the eye is at rest, as in sleep, or even when the eye-lids are shut, the sensation on the retina being then neglected, the voluntary muscles resign their office, and the involuntary muscles draw the pupil under the upper eye-lid. This is the condition of the organ during perfect repose.

* Since this paper was read, a case has occurred in the Middlesex Hospital, under the care of my colleague, Dr. MACMICHAEL, which shows the consequences of the eye and eye-lids being rendered immoveable. In this case the surface of the eye is totally insensible, and the eye remains fixed, and directed straight forwards, whilst the vision is entire. The outward apparatus being without sensibility and motion, and the surface not cleared of irritating particles, inflammation has taken place, and the cornea is becoming opaque ; thus proving the necessity of the motions of the eye to the preservation of the organ. Another curious circumstance, illustrative of the observations made above, is, that when both eyes are shut, the eye affected continues to be sensible of a red light coming through the eye-lid, whilst the sound eye is in darkness. The reason of this I apprehend to be : the eye which possesses its natural motions is turned up, but the eye which continues fixed, looking forwards, receives the light through the transparent eye-lid ; and thus it appears that the dropping of the eye-lid would make an imperfect curtain, if unaccompanied by the turning up of the eye-ball during repose.

The interest of this case will be increased by the considerations in the Second Part of this Paper.

On the other hand, there is an inseparable connection between the exercise of the sense of vision and the exercise of the voluntary muscles of the eye. When an object is seen, we enjoy two senses ; there is an impression upon the retina ; but we receive also the idea of position or relation which it is not the office of the retina to give. It is by the consciousness of the degree of effort put upon the voluntary muscles, that we know the relative position of an object to ourselves. The relation existing between the office of the retina and of the voluntary muscles, may be illustrated in this manner.

Let the eyes be fixed upon an illuminated object until the retina be fatigued, and in some measure exhausted by the image, then closing the eyes, the figure of the object will continue present to them : and it is quite clear that nothing can change the place of this impression on the retina. But notwithstanding that the impression on the retina cannot be changed, the idea thence arising may. For by an exertion of the voluntary muscles of the eye-ball, the body seen will appear to change its place, and it will, to our feeling, assume different positions according to the muscle which is exercised. If we raise the pupil, we shall see the body elevated, or if we depress the pupil, we shall see the body placed below us ; and all this takes place while the eye-lids are shut, and when no new impression is conveyed to the retina. The state of the retina is here associated with a consciousness of muscular exertion ; and it shows that vision in its extended sense is a compound operation, the idea of position of an object having relation to the activity of the muscles.

We may also show, by varying this experiment, that an agitated state of the muscles, or a state of action where the muscles are at variance or confused, affects the idea of the

image. If we look on the luminous body so as to make this impression on the retina, and then cover the face so as to exclude the light, keeping the eye-lids open, and if we now squint, or distort the eyes, the image which was vividly impressed upon the retina instantly disappears as if it were wiped out. Does not this circumstance take place, because the condition of the muscles thus unnaturally produced, being incongruous with the exercise of the retina, disturbs its operation ?

If we move the eye by the voluntary muscles, while this impression continues on the retina, we shall have the notion of place or relation raised in the mind ; but if the motion of the eye-ball be produced by any other cause, by the involuntary muscles, or by pressure from without, we shall have no corresponding change of sensation.

If we make the impression on the retina in the manner described, and shut the eyes, the image will not be elevated, although the pupils be actually raised, as it is their condition to be when the eyes are shut, because there is here no sense of voluntary exertion. If we sit at some distance from a lamp which has a cover of ground glass, and fix the eye on the centre of it, and then shut the eye and contemplate the phantom in the eye ; and if, while the image continues to be present of a fine blue colour, we press the eye aside with the finger, we shall not move that phantom or image, although the circle of light produced by the pressure of the finger against the eye-ball moves with the motion of the finger.

May not this be accounted for in this manner : the motion produced in the eye-ball not being performed by the appropriate organs, the voluntary muscles, it conveys no sensation of

change to the sensorium, and is not associated with the impression on the retina, so as to affect the idea excited in the mind? It is owing to the same cause that, when looking on the lamp, by pressing one eye, we can make two images, and we can make the one move over the other. But, if we have received the impression on the retina so as to leave the phantom visible when the eye-lids are shut, we cannot, by pressing one eye, produce any such effect. We cannot, by any degree of pressure, make that image appear to move, but the instant that the eye moves by its voluntary muscles, the image changes its place; that is, we produce the two sensations necessary to raise this idea in the mind; we have the sensation on the retina combined with the consciousness or sensation of muscular activity.

These experiments and this explanation of the effect of the associated action of the voluntary muscles of the eye-ball, appear to me to remove an obscurity in which this subject has been left by the latest writers. In a most scientific account of the eye and of optics, lately published, it is said on this question, "we know nothing more than that the mind residing, as it were, in every point of the retina, refers the impression made upon it, at each point, to a direction coinciding with the last portion of the ray which conveys the impression." The same author says "KEPLER justly ascribed erect vision from an inverted image to an operation of the mind by which it traces the rays back to the pupil, and thus refers the lower part of the image to the upper side of the eye." What can be here meant by the mind following back the ray through the humors of the eye? It might as well follow the ray out of the eye, and like the spider feel along

the line. A much greater authority says we puzzle ourselves without necessity. "We call that the lower end of an object which is next the ground." No one can doubt that the obscurity here, is because the author has not given himself room to illustrate the subject by his known ingenuity and profoundness. But it appears to me, that the utmost ingenuity will be at a loss to devise an explanation of that power by which the eye becomes acquainted with the position and relation of objects, if the sense of muscular activity be excluded, which accompanies the motion of the eye-ball.

Let us consider how minute and delicate the sense of muscular motion is by which we balance the body, and by which we judge of the position of the limbs, whether during activity or rest. Let us consider how imperfect the sense of touch would be, and how little of what is actually known through the double office of muscles and nerves, would be attained by the nerve of touch alone, and we shall be prepared to give more importance to the recti muscles of the eye, in aid of the sense of vision: to the offices performed by the frame around the eye-ball in aid of the instrument itself.

Of the expression of the eye, and of the actions of the oblique muscles in disease.

If, as I have alleged, the uses of the oblique muscles of the eye have been misunderstood, and if, as I hope presently to prove, the distinctions of the nerves have been neglected, the symptoms of disease, and the sources of expression in the eye, must remain to be explained.

During sleep, in oppression of the brain, in faintness, in debility after fever, in hydrocephalus, and on the approach of death, the pupils of the eyes are elevated. If we open the

eye-lids of a person during sleep or insensibility, the pupils will be found elevated. Whatever be the cause of this, it will be found that it is also the cause of the expression in sickness, and pain, and exhaustion, whether of body or mind : for then the eye-lids are relaxed and fallen, and the pupils elevated so as to be half covered by the upper eye-lid. This condition of the eye during its insensible unexercised state, we are required to explain.

It is a fact familiar to pathologists, that when debility arises from affection of the brain, the influence is greatest on those muscles which are, in their natural condition, most under the command of the will. We may perceive this in the progressive stages of debility in the drunkard, when successively the muscles of the tongue, the eyes, the face, the limbs, become unmanageable ; and, under the same circumstances, the muscles which have a double office, as those of the chest, lose their voluntary motions, and retain their involuntary motions, the force of the arms is gone long before the action of breathing is affected.

If we transfer this principle, and apply it to the muscles of the eye, we shall have an easy solution of the phenomena above enumerated. The recti are voluntary muscles, and they suffer debility before the oblique muscles are touched by the same condition ; and the oblique muscles prevailing, roll the eye.

If it be farther asked, why does the eye roll upwards and inwards ? We have to recollect, that this is the natural condition of the eye, its position when the eye-lids are shut and the light excluded, and the recti at rest and the obliqui balanced.

Although I am aware that medical histories do not often lead

to the improvement of strict science, yet I am tempted to describe the condition of a patient now under my care, because it exhibits a succession of those phenomena which we seek to explain. He presented himself to me in the hospital, with a distinct squint, the left eye being distorted from the object. On the eye-lid of the right eye there was a deep and open ulcer ; the man was in danger of losing the right eye, and required prompt assistance ; but before he could be brought under the influence of medicine, the inflamed sore became deeper and the cornea opaque. The superior rectus muscle being, as I suppose, injured by the encreasing depth of the sore, the pupil became permanently depressed. The sight of the right eye being now lost, the left eye came into use ; it was directed with precision to objects, he had no difficulty in using it, and it daily became stronger.

After a few weeks, medicine having had its influence, the sore on the upper eye-lid of the right eye healed, the inflammation and opacity of the eye gradually diminished, the light became again visible to him ; first it was yellow, and then a deep purple. And now the muscles resumed their influence, and the eye was restored to parallel motion with the other, and so as considerably to embarrass the vision. But the inflammation of the upper eye-lid had been so great, as considerably to diminish its mobility ; and what appeared most extraordinary, the lower eye-lid assumed the office of the upper one, and a very unusual degree of motion was remarked in it. It was depressed when he attempted to open the eye, and elevated and drawn towards the nose, when he closed the eye. But the upper eye-lid was not only stiff, but diminished in breadth ; so that notwithstanding the remarkable elevation of the lower

eye-lid, their margins were not brought together, and we could perceive the motion of the eye-ball ; in his attempt to close the eye we saw the pupil elevated, and the white part of the eye exposed.

I shall now attempt the explanation of some of these phenomena :

The impression upon the left eye had been weak from infancy, and the retina being unexercised, the recti or voluntary muscles wanted their excitement, and were deficient in activity ; the involuntary muscles therefore prevailed, and the pupil was turned upwards and inwards, and consequently removed from the axis of the other eye. But when that other eye became obscured, the left eye being the only inlet to sensation, the attention became directed to the impression on the retina, the voluntary muscles were excited to activity, and they brought the eye to bear upon objects. This eye improved daily, because the natural exercise of a part is its stimulus to perfection, both in function and in growth. When the right eye became transparent and the light was admitted, the voluntary muscles of that eye partook of their natural stimulus, and commenced that effort in search of the object, which in the course of a few days brought the eye to its proper axis, and both eyes to parallelism.

The next thing that attracts our attention in this short narrative, is the revolving of the eye-ball. It has been explained in a former part of the paper, that when the eye-lids are shut, the recti or voluntary muscles resign their office, and the inferior oblique muscle gains power, and the eye-ball traverses so as to raise the pupil. It will not have escaped observation, that the pupil of this eye was depressed, and

could not be elevated for the purpose of vision, owing, as we have supposed, to the injury of the rectus attollens, at the same time that it was thus raised involuntarily, in the attempt to shut the eye ; a proof that this insensible motion is performed by the lower oblique muscle, and not the superior rectus muscle.

The circumstance of the lower eye-lid assuming the functions of the upper one, and moving like the lower eye-lid of a bird, reminds me of an omission in the account of authors. They have sought for a depressor of the inferior eye-lid, which has no existence, and is quite unnecessary ; for the motion of the *M. elevator palpebræ superioris* opens wide the eye-lids, and depresses the lower eye-lid, at the same time that it elevates the upper eye-lid. If we put the finger on the lower eye-lid when the eye is shut, and then open the eye, we shall feel that during this action the eye-ball is pushed outwards ; and we may observe, that the lower eye-lid is so adapted as to slip off the convex surface of the ball, and is consequently depressed. The reason of this is, that the muscle which raises the upper eye-lid passes over a considerable part of the upper and back part of the eye-ball, and the origin and insertion of the muscle being under the highest convexity of the ball, that body must be pressed forwards in proportion to the resistance of the upper eye-lid to rise. In the preceding case the upper eye-lid being stiff and unyielding, both the origin and the insertion of the *elevator palpebræ* became fixed points ; consequently, the action of the muscle fell entirely on the eye-ball itself, whereby it was forced downwards and forwards in an unusual manner, and so depressed the lower eye-lid to an unusual degree. Thus the muscle became a *depressor* of the inferior eye-lid, instead of an *elevator* of the

upper eye-lid ! The motion of elevation in the lower eye-lid was of course performed by an encreased action of the lower portion of the *orbicularis palpebrarum*.

The Author has to regret that these minute circumstances regarding the action of the muscles of the eye have led him to so great a length ; he hopes they are not altogether without interest in themselves, while the discussion will afford him secure ground for establishing an arrangement of the nerves of the eye, and will enable him to distinguish them according to their uses.

EXPLANATION OF PLATE XXI.

Fig. 1. The muscles of the eye seen in front.

A. B. C. D. The recti muscles ; voluntary muscles.

E. The superior oblique muscle or trochlearis.

a. The trochlea cut off from the bone and left attached to the tendon. It is a loop through which the tendon runs.

b. The tendon of the trochlearis muscle expanding and running to its insertion.

G. The inferior oblique muscle. It is seen, like the tendon of the superior oblique, to run backwards and outwards.

Fig. 2. The muscles of the eye seen in profile.

A. B. . D. Three of the recti muscles. They arise together from the periosteum of the bottom of the orbit, and are inserted into the anterior part of the sclerotic coat of the eye.

E. The superior oblique muscle, or trochlearis.

a. The trochlea.

b. The reflected tendon inserted into the back and outer part of the sclerotic coat.

G. The inferior oblique muscle.

c. Its origin from the anterior part of the orbit.

d. Its insertion into the back and outer part of the eye-ball.

Fig. 1.

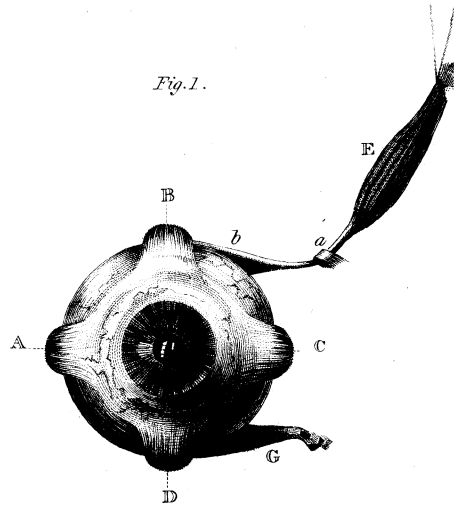


Fig. 2.

